Amendments to the Claims

This listing of claims will replace all prior versions and listings of claims in the application.

Listing of Claims:

1. (currently amended) An improved echo control system ~~of the type~~ including:

an echo-containing near signal input;

an echo canceller, coupled to a far signal reference, producing an echo estimate signal output representative of the echo contained in the near signal;

a signal coupling node, coupled to the near signal input and the echo estimate signal output, producing an echo-canceled signal output having an echo residue;

an echo shaping filter, coupled to the echo-canceled signal output, reducing the echo residue and providing an echo-suppressed signal output, the echo shaping filter having a spectral response determined by filter coefficients; and

a background filter, coupled to:

(a) an error signal representative of the difference between:

(i) the echo canceled signal, and

(ii) a signal representative of background filter spectral response, and

(b) an adaptive control module producing a reference signal output that is a weighted sum of:

(i) the echo-containing signal, and

(ii) the echo canceled signal,

the background filter updating the filter coefficients of the echo shaping filter responsive to a normalized least mean square (NLMS) algorithm;

wherein the improvement comprises:

determining, in the adaptive control module, a reference signal weight for the weighted sum, the weight being proportional to the far signal reference; and an estimate of the norm of an echo canceller error vector, and inversely proportional to en estimate of a residue of the echo canceller; and

using a non-linear normalized convergence term in the NLMS algorithm.

2. (original) An improved echo control system according to claim 1, wherein the echo canceller is a finite impulse response (FIR) filter.

3. (original) An improved echo control system according to claim 1, wherein the echo shaping filter is a finite impulse response (FIR) filter.

4. (original) An improved echo control system according to claim 1, wherein the background filter is a finite impulse response (FIR) filter.

5. (original) An improved echo control system according to claim 1, wherein the echo canceller error vector is determined as:

$$\Delta w(k) = \mathbf{w}_{ep} - \mathbf{w}(k)$$

where $\Delta w(k)$ represents the echo canceller error vector, $\mathbf{w}_{\mathbf{ep}}$ represents a physical echo path identified by the echo canceller, and **w**(k) the echo canceller response.

6. (original) An improved echo control system according to claim 1, wherein the reference signal weight is determined as:

$$\alpha(k) = \frac{\beta \, \|\Delta \mathbf{w}(k)\| \overline{x}_s(k)}{\overline{e}_s(k)}$$

where $\alpha(k)$ represents the reference signal weight, β represents a constant normalizing term, $\|\Delta \mathbf{w}(k)\|$ represents an estimate of the norm of the echo canceller error vector, $\overline{x}_s(k)$ represents a short-term average magnitude of the far signal reference, and $\overline{e}_s(k)$ represents a short-term average magnitude of the echo canceller residue.

7. (original) An improved echo control system according to claim 6, wherein the echo canceller error vector is determined as:

$$\left| \frac{N + N_T}{N_T} \sum_{i=1}^{N_T} |w_i(k)| \right|$$

8. (original) An improved echo control system according to claim 1, wherein the NLMS update algorithm is:

$$\mathbf{h}(k+1)=\mathbf{h}(k)+\frac{\mu}{\zeta+\mathbf{z}(k)^{T}\mathbf{z}(k)}\mathbf{z}(k)e_{h}(k)$$

where $\mathbf{h}(k)$ represents the echo shaping filter having an order L_H, $\mathbf{z}(k)$ represents a vector representing the L_H most recent values of the reference signal output, $e_h(k)$ represents the error signal, ζ represents a non-negative constant, and $\frac{\mu}{\zeta+\mathbf{z}(k)^{T}\mathbf{z}(k)}$ represents a normalized convergence coefficient.

9. (currently amended) An improved method of echo control ~~of the type~~ including:

providing an echo-containing near signal input;

producing, with an echo canceller coupled to a far signal reference, an echo estimate signal output representative of the echo contained in the near signal;

producing, with a signal coupling node coupled to the near signal input and the echo estimate signal output, an echo-canceled signal output having an echo residue;

reducing, with an echo shaping filter coupled to the echo-canceled signal output, the echo residue and providing an echo-suppressed signal output, the echo shaping filter having a spectral response determined by filter coefficients; and

providing a background filter, coupled to:

(a) an error signal representative of the difference between:

(i) the echo canceled signal, and

(ii) a signal representative of back ground filter spectral response, and

(b) an adaptive control module producing a reference signal output that is a weighted sum of:

(i) the echo-containing signal, and

(ii) the echo canceled signal,

the background filter updating the filter coefficients of the echo shaping filter responsive to a normalized least mean square (NLMS) algorithm;

wherein the improvement comprises:

determining, in the adaptive control module, a reference signal weight for the weighted sum, the weight being proportional to the far signal reference; and an estimate of the norm of an echo canceller error vector, and inversely proportional to en estimate of a residue of the echo canceller; and

using a non-linear normalized convergence term in the NLMS algorithm.

10. (currently amended) An improved echo control method according to claim ~~1~~9, wherein the echo canceller is a finite impulse response (FIR) filter.

11. (currently amended) An improved echo control method according to claim ~~1~~9, wherein the echo shaping filter is a finite impulse response (FIR) filter.

12. (currently amended) An improved echo control method according to claim ~~1~~9, wherein the background filter is a finite impulse response (FIR) filter.

13. (currently amended) An improved echo control method according to claim ~~1~~9, wherein the echo canceller error vector is determined as:

$$\Delta w(k) = \mathbf{w}_{ep} - \mathbf{w}(k)$$

where $\Delta w(k)$ represents the echo canceller error vector, $\mathbf{w}_{\mathrm{ep}}$ represents a physical echo path identified by the echo canceller, and $\mathbf{w}(k)$ the echo canceller response.

14. (currently amended) An improved echo control method according to claim ~~1~~9, wherein the reference signal weight is determined as:

$$\alpha(k) = \frac{\beta \|\Delta \mathbf{w}(k)\| \bar{x}_s(k)}{\bar{e}_s(k)}$$

where $\alpha(k)$ represents the reference signal weight, β represents a constant normalizing term, $\|\Delta \mathbf{w}(k)\|$ represents an estimate of the norm of the echo canceller error vector, $\bar{x}_s(k)$ represents a short-term average magnitude of the far signal reference, and $\bar{e}_s(k)$ represents a short-term average magnitude of the echo canceller residue.

15. (currently amended) An improved echo control method according to claim ~~6~~14, wherein the echo canceller error vector is determined as:

$$\left| \frac{N + N_T}{N_T} \sum_{i=1}^{N_T} |w_i(k)| \right|$$

16. (currently amended) An improved echo control method according to claim ~~1~~9, wherein the NLMS update algorithm is:

$$\mathbf{h}(k+1) = \mathbf{h}(k) + \frac{\mu}{\zeta + \mathbf{z}(k)^T \mathbf{z}(k)} \mathbf{z}(k) e_h(k)$$

where $\mathbf{h}(k)$ represents the echo shaping filter having an order L_H, $\mathbf{z}(k)$ represents a vector representing the L_H most recent values of the reference signal output, $e_h(k)$ represents the error signal, ζ represents a non-negative constant, and $\frac{\mu}{\zeta + \mathbf{z}(k)^T \mathbf{z}(k)}$ represents a normalized convergence coefficient.